ROENTGEN-RAY STUDIES OF BRONCHIAL FUNCTION.[1]

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Several clinical problems, among them the accumulation of abundant bronchial secretion in laryngeal diphtheria and the formation of bronchiectases and antra, seem to depend upon a more correct understanding of the processes by which the lungs evacuate themselves.

Fluoroscopic observations and studies of the radiographs of an injected tracheobronchial tree in a patient suffering from a malignant tracheo-esophageal fistula seemed to disclose what we interpreted as the evidence of a peristaltic action in the bronchi. Another case, Beeler's,[2] has been reported, but the reduced reproduction of the bronchi does not lend itself to interpretation of detail. Both our own case and that of Beeler died as the result of lung suppuration.

This is not remarkable in view of the fact that infected fluids were injected and in both cases, it is believed that the fistula interfered with the proper emptying of the lung.

Rosenberg, in 1887, was the first to inject the bronchi therapeutically. Chevalier Jackson reported the insufflation of bismuth powder and recommended its utilization in diagnosis. The experiments of C. A. Waters, S. Bayne-Jones[3] and L. G. Rowntree were performed to study the anatomy of the bronchial tree and record the use of thorium and iodoform and bismuth pastes. Some of the dogs in which iodoform was used died.

Our first experiment was with a fox terrior bitch, 20 c.c. of thorium nitrate in sodium citrate solution being injected into the bronchial tree through a catheter. In spite of the prompt evacuation of the thorium solution, by posture, the animal experienced marked dyspnea, rapid irregular heart action and died about fifteen minutes later. A slide of this lung showed that the thorium had already penetrated the pulmonary vessels by osmosis. In another dog, which died from chloroform anesthesia, the excised lungs were filled with thorium solution and radiographed. The radiogram was unsatisfactory because the solution spread beyond the confines of the bronchial tree, invading the parenchyma.

[1] Read before the Section on Medicine, New York Academy of Medicine, November 18, 1919.
[2] Jour. Am. Med. Assn., vol. xlv, p. 178.
[3] Arch. Int. Med., April 16, 1917, p. 538.

A second dog injected with a small quantity of thorium survived until the following morning. When the lungs at postmortem were injected with barium in acacia they showed details of lung structure

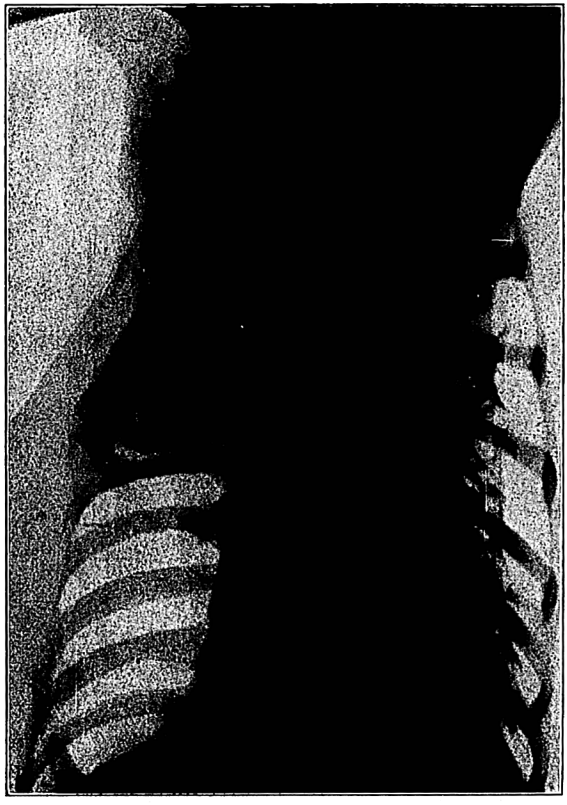

FIG. 1.—No. 8. October 16, 1919. Black and white fox terrier, five and a half minutes after injection of 1 mil. of adrenalin chloride. Dog had received 10 c.c. of barium in olive oil suspension. The terminal bronchi are contracted.

as far as the alveoli and served to visualize the conception of lung structure very much as do corrosion specimens.

The lungs of a fourth dog were injected with barium in gelatin

after chloroform anesthesia, using the formula employed by Louis Gross in his injections of the vascular trees of excised organs. This experiment gave pictures which were too indefinite for satisfactory study, and the dog so injected died of a pneumonia involving the area injected six days later. This was attributed to a decomposition of the gelatin.

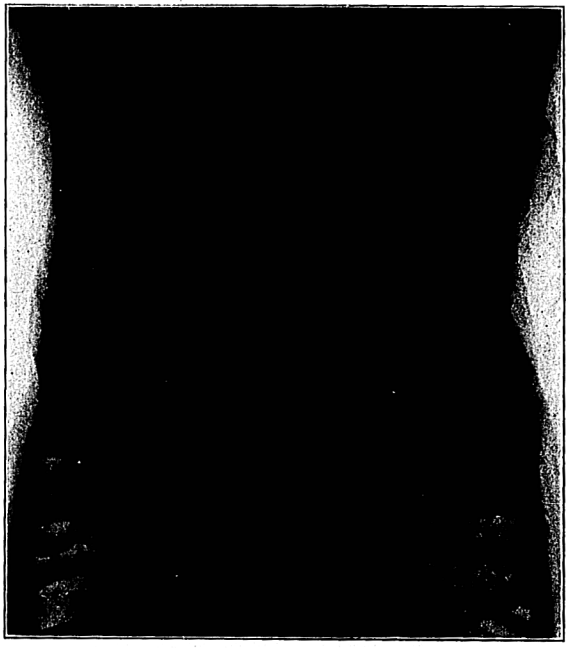

FIG. 2.—No. 9. October 18, 1919. Black and white fox terrier after injection of adrenalin, in deep inspiration.

It was now decided to employ a medium which would not putrefy and which could readily carry a larger amount of barium. It was felt that iodoform poisoning had probably contributed to the death of the dogs in the Waters, Bayne-Jones and Rowntree experiments. Barium sulphate was triturated with anhydrous olive oil until a thick, smooth paste was formed. This paste was injected into anesthetized dogs directly into a bronchus in amounts of 5 to 10 c.c., depending upon the size of the dog. In one dog barium was tri-

turated with liquid petrolatum to form a thick paste. This was as satisfactory as the olive oil, and more readily sterilized. Only one of the dogs has died. Our dogs have been reinjected at an interval of three to seven days. In one dog the experiment was repeated twice in the same evening, when it was found that the lung had emptied itself after an hour. So far in our experiments the procedure

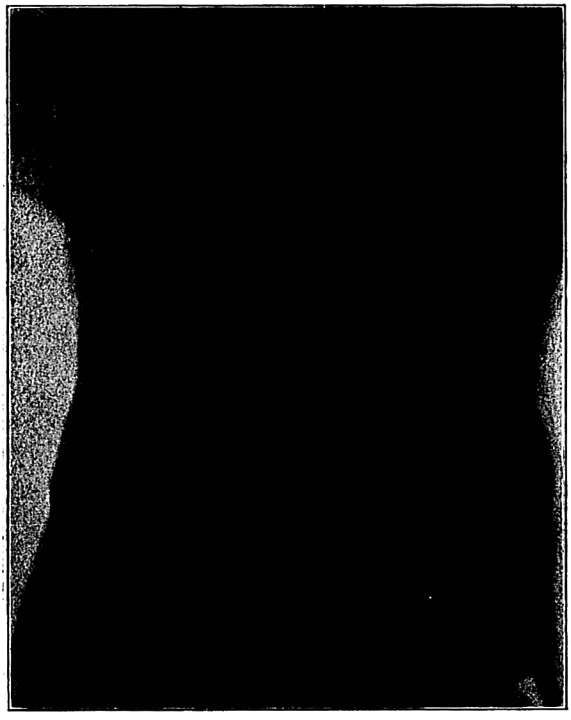

FIG. 3.—No. 10. October 18, 1919. Black and white fox terrier after injection of adrenalin, deep expiration. Note that ribs are elevated and bronchi are narrow in contrast to appearance in No. 9.

seems relatively innocuous in healthy dogs. One small dog which was injected with a large amount of barium in oil, retained sufficient in the right lower lobe to cast a shadow, which radiographically simulated a pneumonia for several weeks. After four subsequent injections the dog wasted away and finally died. A roentgen ray

of the lung shows a general filling of the alveoli with barium. The external surface of the lung appeared white in places.

The dogs were studied fluoroscopically and radiographs were taken. Most of the dogs tolerated these injections excellently.

Under the fluoroscope we have studied the movements in the bronchi and have observed the following phenomena:

FIG. 4.—No. 15. October 28, 1919. Male brindle pup anesthetized with ether, 10 minims of adrenalin chloride; five minutes later, 5 c.c. of barium in oil, which went into the stomach; ten minutes later, 10 minims of adrenalin chloride; then tracheal injection of 10 c.c. of barium in oil; immediate plate. Terminal bronchi are spastic so that barium may not enter.

1. If the left diaphragmatic bronchus and its branches are injected it is seen to move laterally with each pulsation of the heart.

2. There is, synchronous with respiration, a bellows-like expansion and contraction of the trachea and bronchi, which is very obvious in the relaxed bronchus immediately after injection, and especially if the anesthetic has not completely worn off (Figs. 2 and 3).

This expansion and compression of the bronchi is probably produced by costal breathing and the suppression of this bellows-like

action when movements of the ribs are limited may have deleterious effects. It seems possible to infer, from our observations, that the spastic contraction of the bronchus is as important in limiting the expansibility of the lung as it is in diminishing the caliber of the bronchi. Observations on chronic stenosis of the larynx at the Willard Parker Hospital by one of us (J. G. M. B.) have established

FIG. 5.—No. 16. October 28, 1919. Adrenalin given before tracheal instillation of barium. Terminal bronchi contracted and not filled.

the fact that a reduction in the tracheal lumen to one-third its size does not interfere with adequate respiration. Our observations may prove important in explaining the pathology of bronchiectasis and

recall von Basch's views on the importance of lost distensibility in the production of asthma and emphysema.

3. In addition to the two movements of the bronchus mentioned a third movement of larger cycle was observed. This is a movement

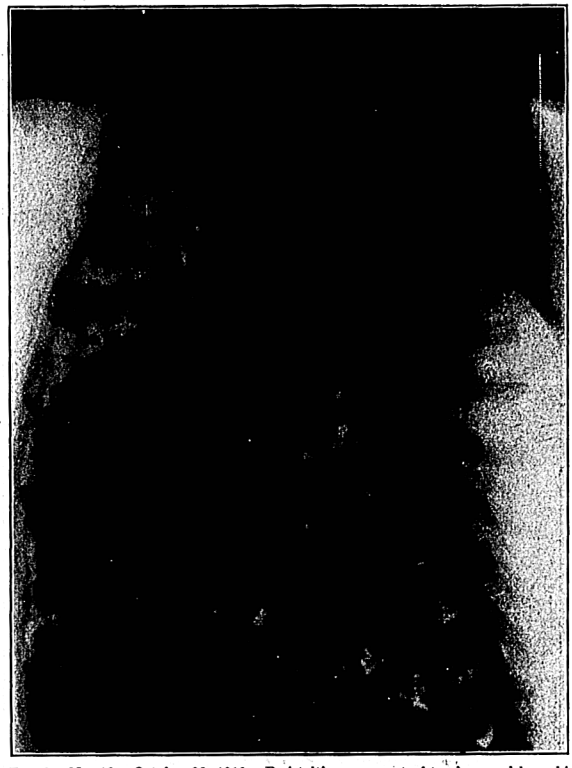

FIG. 6.—No. 18. October 28, 1919. Peristaltic movement of trachea, and bronchi; lateral view.

of long peristaltic wave (10 cm.), though its amplitude is small. It is visible immediately after the injection of barium, and seems to be a potent factor in the evacuation of the bronchi and trachea. It is readily seen if a given point in the bronchus is kept under observation, at this point the bronchus or trachea is seen to contract and dilate

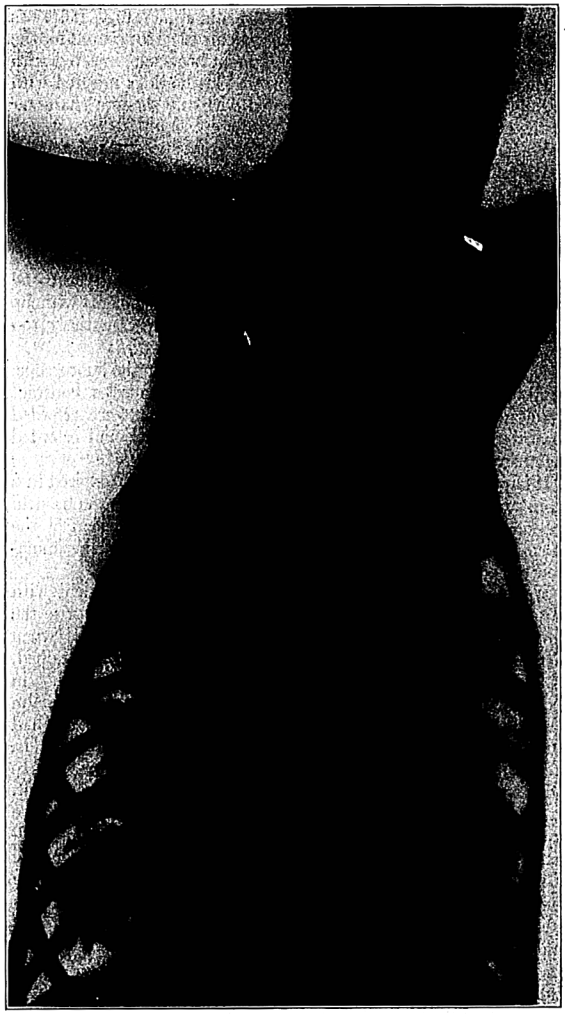

FIG. 7.—October 28, 1919. Same conditions on very rapid plates demonstrating peristaltic wave in trachea and bronchi; anterior view.

slowly, independent of cough, respiration and swallowing. It travels up the bronchial tree. This movement seems to us to account for the wave-like structure observed in the human bronchus injected with barium in acacia and also to be revealed in the dogs injected with barium paste, and may be contrasted with the sac-like character of the excised injected bronchi.

We submit a plate (Fig. 7), taken with great speed, which reveals sharply this peristaltic wave. We regret there is no available method of radiographic cinemetography, so that these movements may be analyzed more accurately. The lungs seem to empty themselves largely by means of this peristaltic movement, for even when the dogs are held upright so that gravity which readily empties a dog's lung cannot act, successive masses of the injection are seen to be expelled from the larynx and to travel down the esophagus without evidence of accompanying cough. This movement is entirely too rapid to be attributed to ciliary action.

4. We have also studied bechic movement under the fluoroscope. Under their influence the chest and abdominal muscles contract simultaneously, so that the lung and bronchial branches are crowded toward the trachea. These branches are shortened and crowded together.

It is probable that the air contained in the alveoli is expired in a more concentrated blast. Under the influence of cough the bronchi are emptied more rapidly. It is possible that contraction of the bronchial muscles directly influences by traction or nervous stimulation the contraction of the chest parietes.

We injected adrenalin in dogs after filling their bronchi with barium and hoped to see the bronchi dilated. To our surprise the bronchi appeared smaller. Notwithstanding the fact that when pictures were taken, the same phase of respiration was obtained, as shown by the position of the ribs. This observation is not in accord with that accepted as the physiological action of adrenalin on bronchial muscles. At first it was thought that the lung had emptied itself in the interval allowed for the adrenalin to act. In order to avoid this confusing factor, adrenalin was administered to a dog before the barium was injected. We obtained the same result. In one dog adrenalin caused an increased rate of emptying of the bronchus with coughing. In another dog after giving benzyl-benzoate, which is alleged and was observed to cause bronchial dilatation, adrenalin was given and the bronchi were found to be contracted. In another dog bronchial spasm was induced by administering 1 mg. of muscarin intravenously. This was associated with considerable coughing and persistent general muscular twitching. An intravenous dose of adrenalin relaxed the spasm of the bronchi and caused the twitching to disappear. (See illustrations.)

We are aware of the shortcomings and paucity of our observations, but we have concluded to report them, with the conviction

that the observations contribute to a more correct understanding of the physiology of the bronchi.

In conclusion we have observed:

1. A bellows-like action in the trachea and bronchi which may be limited by contraction of the bronchial muscles.

2. A peristaltic action of the bronchial muscles, which seems adequate to empty them without invoking ciliary movement.

3. The action of adrenalin, benzyl benzoate, ether and muscarin have been observed by this roentgen-ray method.

The writers wish to record their debt to Dr. William B. Giles and Dr. Louis Griessman for valuable assistance and collaboration.

HETEROPLASTIC BONE FORMATION IN THE FALLOPIAN TUBE.

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In the course of a routine examination of tissues recently removed at operations on the gynecological service of the Barnes Hospital, my curiosity was aroused by the difficulty which I encountered in attempting to cut a block of tissues from a Fallopian tube. Upon a closer inspection what appeared to be a spicule of bone, about 5 mm. wide and less than 1 mm. thick, was seen to protrude from the cut end of the tubal lumen. There were several other foci of similar resistance in the wall of the tube and in the mesosalpinx.

Presentation of the Case. The patient, M. J., a negress, aged thirty-seven years, was admitted to the gynecological service of the Barnes Hospital with complaints of a pain in the left lower quadrant and a firm mass in the lower abdomen. The family and past histories were unimportant. Menstruation started at the age of thirteen, and has been always regular, recurring every twenty-eight days and lasting from seven to twelve days. The flow has been rather profuse as a rule. The patient has not missed any period except in connection with her pregnancies. She has had intermenstrual bleedings for the past three years. The last menstrual period started on August 24, 1919 and was still continuing at the time of admission, September 14. The patient has had three pregnancies, two of which were full term and one a miscarriage. The oldest child is twenty years old and the miscarriage occurred ten years ago. The present illness dates back for three years, with an aching pain in the left lower quadrant. The pain was constant, and on several occasions during